Introduction

The **lower limb** is responsible for supporting body weight, maintaining posture, and producing movements required for locomotion.

Its joints are designed to withstand large mechanical loads while providing a balance between **stability** and **mobility**.

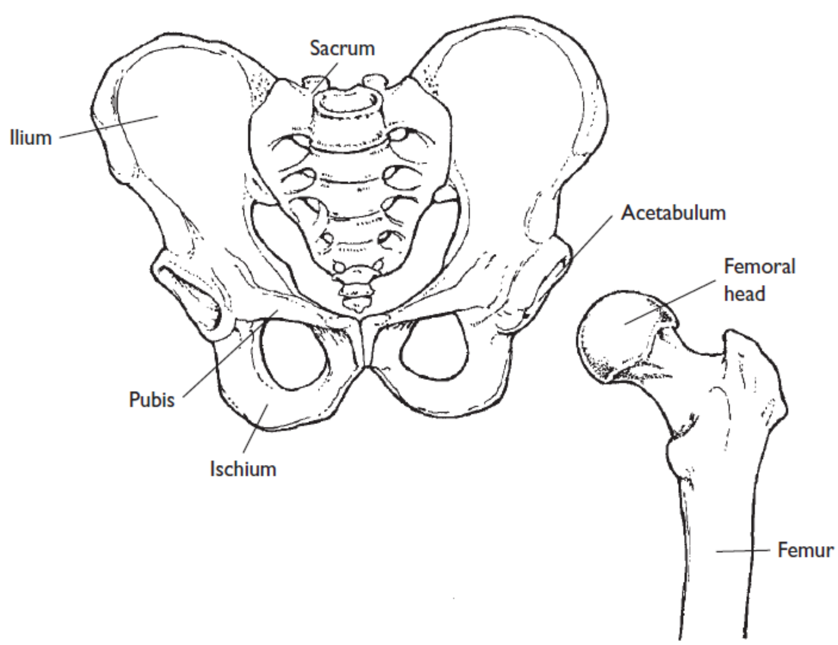
The **hip** and **knee** joints are the major articulations that control the motion of the thigh and leg during standing, walking, running, and lifting.

Biomechanics of the Hip Joint

1. Structure of the Hip

The **hip joint** is a **ball-and-socket articulation** formed between the **head of the femur** and the **acetabulum** of the pelvis.

This structure provides a combination of **high stability** and **multidirectional mobility**. The **acetabulum** faces laterally, anteriorly, and inferiorly, increasing contact with the femoral head (Fig.1: The hip joint structure).



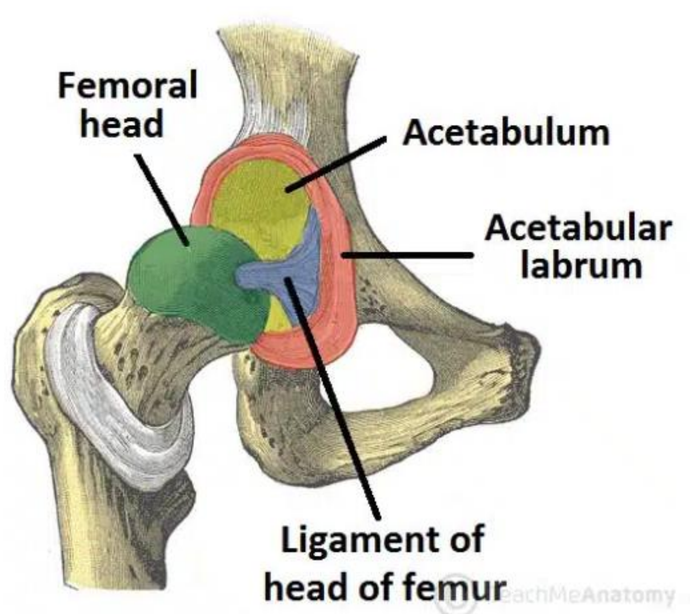
The **acetabular labrum** is a fibrocartilaginous rim that **deepens the socket**, enhances **joint congruency**, and contributes to **shock absorption**.

The joint capsule is reinforced by strong ligaments including the **iliofemoral**, **pubofemoral**, and **ischiofemoral** ligaments, which limit excessive extension, abduction, and internal rotation respectively.

2. Joint Type of the Hip

The hip is classified as a **ball-and-socket synovial joint**, allowing motion in **three anatomical planes**.

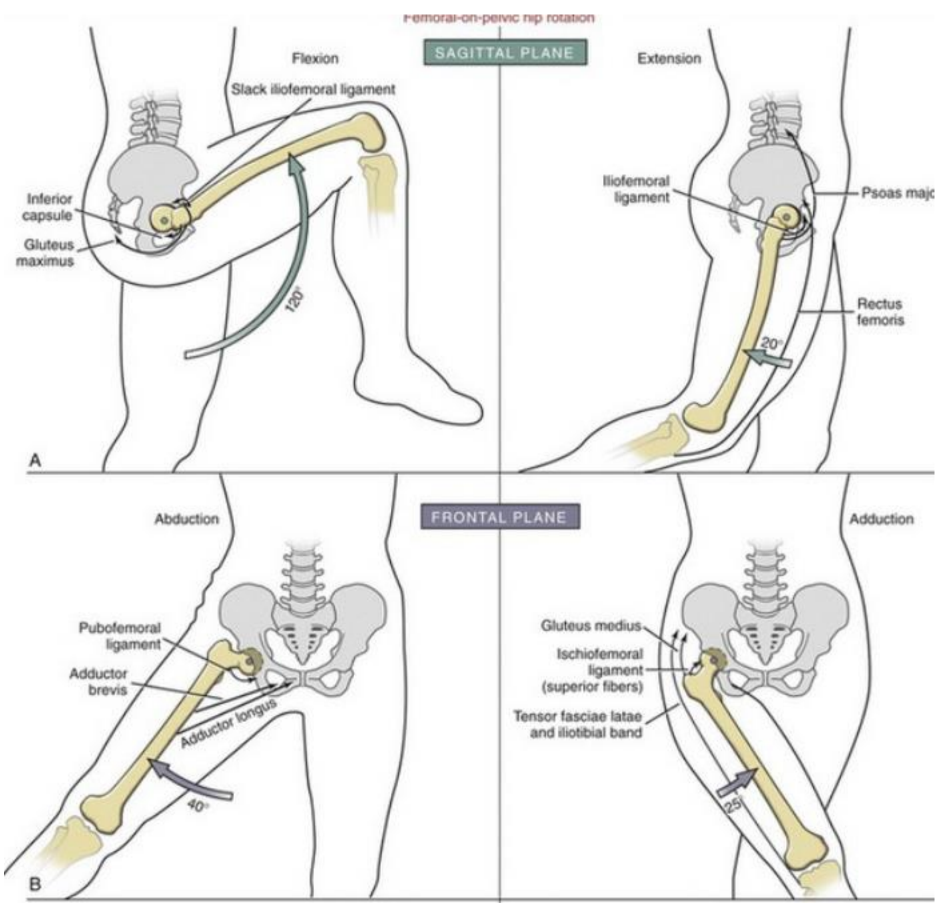
It is a **triaxial joint**, meaning that it permits movement about **three axes**. Its deep socket and strong ligamentous reinforcement make it one of the most stable joints in the body (Fig.2: The acetabulum and femoral head).



3. Movements of the Hip

The hip allows extensive movement in multiple directions:

- **Flexion and Extension** occur in the sagittal plane. Flexion is produced mainly by the **iliopsoas**, while extension is generated by the **gluteus maximus** and **hamstrings**.
- **Abduction and Adduction** occur in the frontal plane and are controlled by the **gluteus medius and minimus** (abduction) and the **adductor group** (adduction).
- **Internal and External Rotation** occur in the transverse plane and involve deep rotator muscles such as the **piriformis** and **gemelli**.
- **Circumduction** is a combination of the above movements forming a conical motion. (Fig.3: Hip motion planes.)



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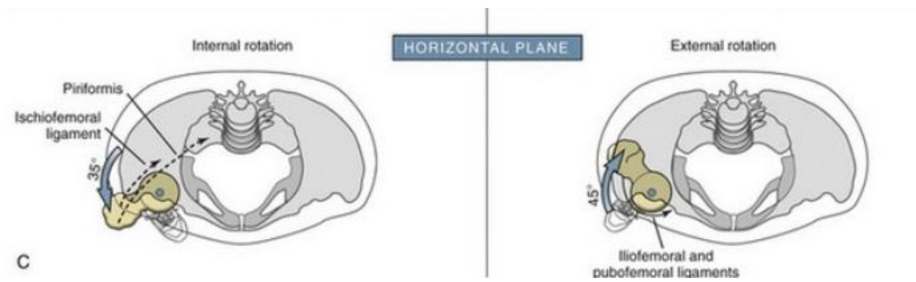
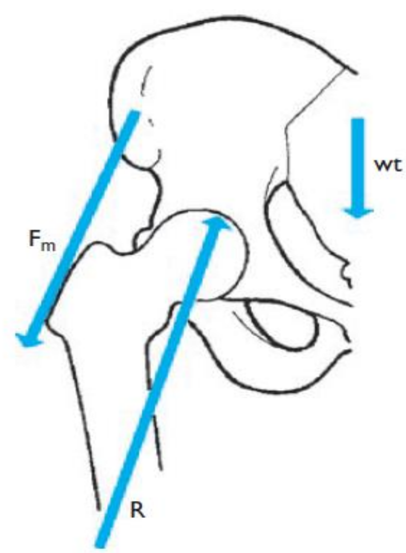


4. Loads on the Hip

The hip supports large mechanical loads due to its role in weight-bearing. Even during quiet standing, each hip carries approximately **one-third of body weight**. During walking and stair climbing, the load increases to **2–4 times body weight**, and may exceed **5 times body weight** during running (Fig.4: Hip loading during gait).

The **abductor muscles** generate significant force during single-leg stance to maintain pelvic stability.

This results in high **joint reaction forces** acting on the hip. Weakness in the abductors can lead to lateral trunk lean and increased joint stress.



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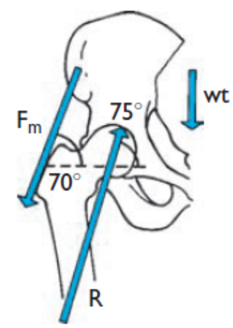
The major forces on the hip during static stance are the weight of the body segments above the hip (with one-half of the weight on each hip), tension in the hip abductor muscles (Fm), and the joint reaction force (R).

SAMPLE PROBLEM .1

How much compression acts on the hip during two-legged standing, given that the joint supports 250 N of body weight and the abductor muscles are producing 600 N of tension?

Known

$$wt = 250\ N$$
$$F_m = 600\ N$$

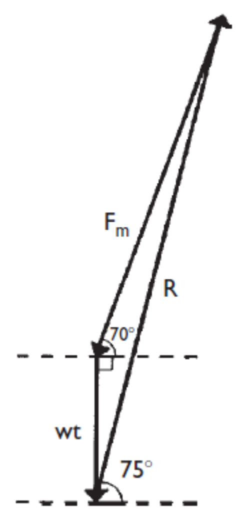


Graphic Solution

Since the body is motionless, all vertical force components must sum to zero and all horizontal force components must sum to zero. Graphically, this means that all acting forces can be transposed to form a closed force polygon (in this case, a triangle). The forces from the diagram of the hip above can be reconfigured to form a triangle.

If the triangle is drawn to scale (perhaps 1 cm = 100 N), the amount of joint compression can be approximated by measuring the length of the joint reaction force (R).

$$R \approx 840\ N$$



Mathematical Solution

The law of cosines can be used with the same triangle to calculate the length of R.

$$R^2 = F_m{}^2 + wt^2 - 2(F_m)(wt)\cos 160°$$
$$R^2 = 600\ N^2 + 250\ N^2 - 2(600\ N)(250\ N)\cos 160°$$
$$R = 839.3\ N$$

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